

Announcements

- HW2 is on Canvas
 - Due date: Friday, Oct. 21
- Exam I
 - Wednesday, Oct. 12
 - In class

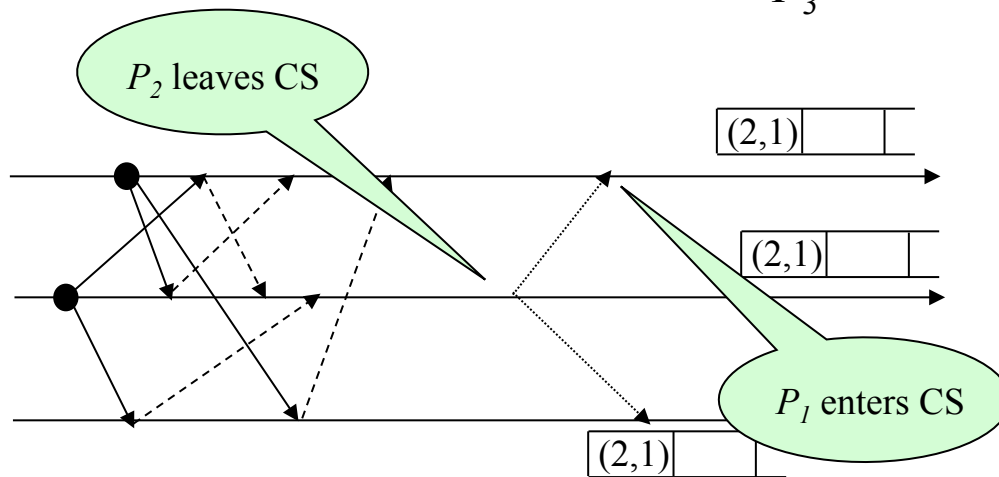
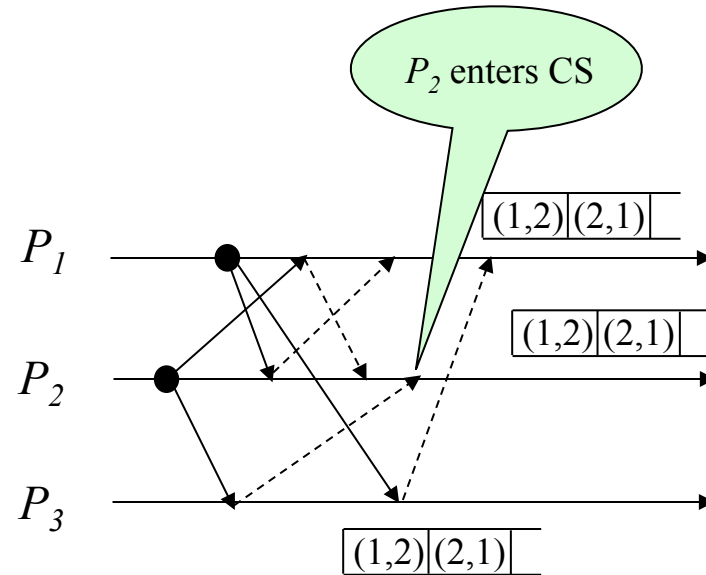
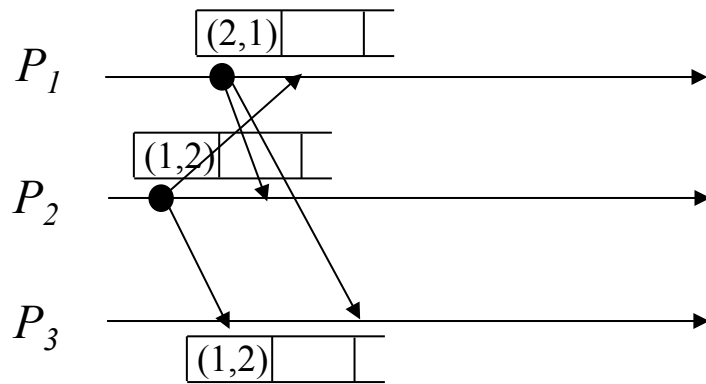
Lamport's Algorithm

- Assumption: messages delivered in FIFO order (no loss messages)
- Requesting the CS
 - P_i sends message **REQUEST**(t_i, i) to other processes, then enqueues the request in its own *request_queue_i*
 - when P_j receives a request from P_i , it returns a timestamped **REPLY** to P_i and places the request in *request_queue_j*
 - *request_queue* is ordered according to (t_i, i)
- A process P_i executes the CS only when:
 - P_i has received a message with timestamp larger than t_i from all other processes
 - its own request is the first of the *request_queue_i*

Lamport's Algorithm (2)

- Releasing the critical section:
 - when done, a process remove its request from the queue and sends a timestamped **RELEASE** message to all
 - upon receiving a **RELEASE** message from P_i , a process removes P_i 's request from the request queue

Lamport's Algorithm Example



Lamport's: proof of correctness

- Proof by contradiction:
 - assume P_i and P_j are executing the CS at the same time
 - assume request timestamp (t_i, i) of P_i is smaller than that of P_j
 - this means both P_i and P_j have their request at the top of the queue
 - FIFO channels + second assumption + P_j executing \Rightarrow request from P_i must be in *request_queue_j*
 - contradiction: P_i request in *request_queue_j* and not at the top of the queue, however we said $\text{timestamp}(P_i) < \text{timestamp}(P_j)$...
- Therefore it cannot be that P_i and P_j are executing the CS at the same time!

About Lamport's Algorithms

- Why FIFO?
- Why Message, not Response?
- Lossy channels work?

- How many messages passed for one CS execution?
 - Can we improve it?

Ricart-Agrawala Algorithm

- Optimization of Lamport's algorithm:

Lamport's Algorithm

Requesting the CS

- P_i sends message **REQUEST**(t_i, i) + enqueues the request in *request_queue_i*
- when P_i receives a request from P_j , it enqueues it and returns a **REPLY** to P_j

P_i executes the CS only when:

- has received a msg with timestamp $> t_i$ from everybody
- its own request is the first in the *request_queue_i*

Releasing the CS:

- when done, a process remove its request from the queue + sends a timestamped **RELEASE** msg. to everybody else
- upon receiving a **RELEASE** message from P_j , a process removes P_j 's request from its request queue

Ricart-Agrawala Algorithm

Requesting the CS

- P_i sends message **REQUEST**(t_i, i)
- when P_i receives a request from P_j , it returns a **REPLY** to P_j if it is not requesting or executing the CS, or if it made a request but with a larger timestamp. Otherwise, the request is **deferred**.

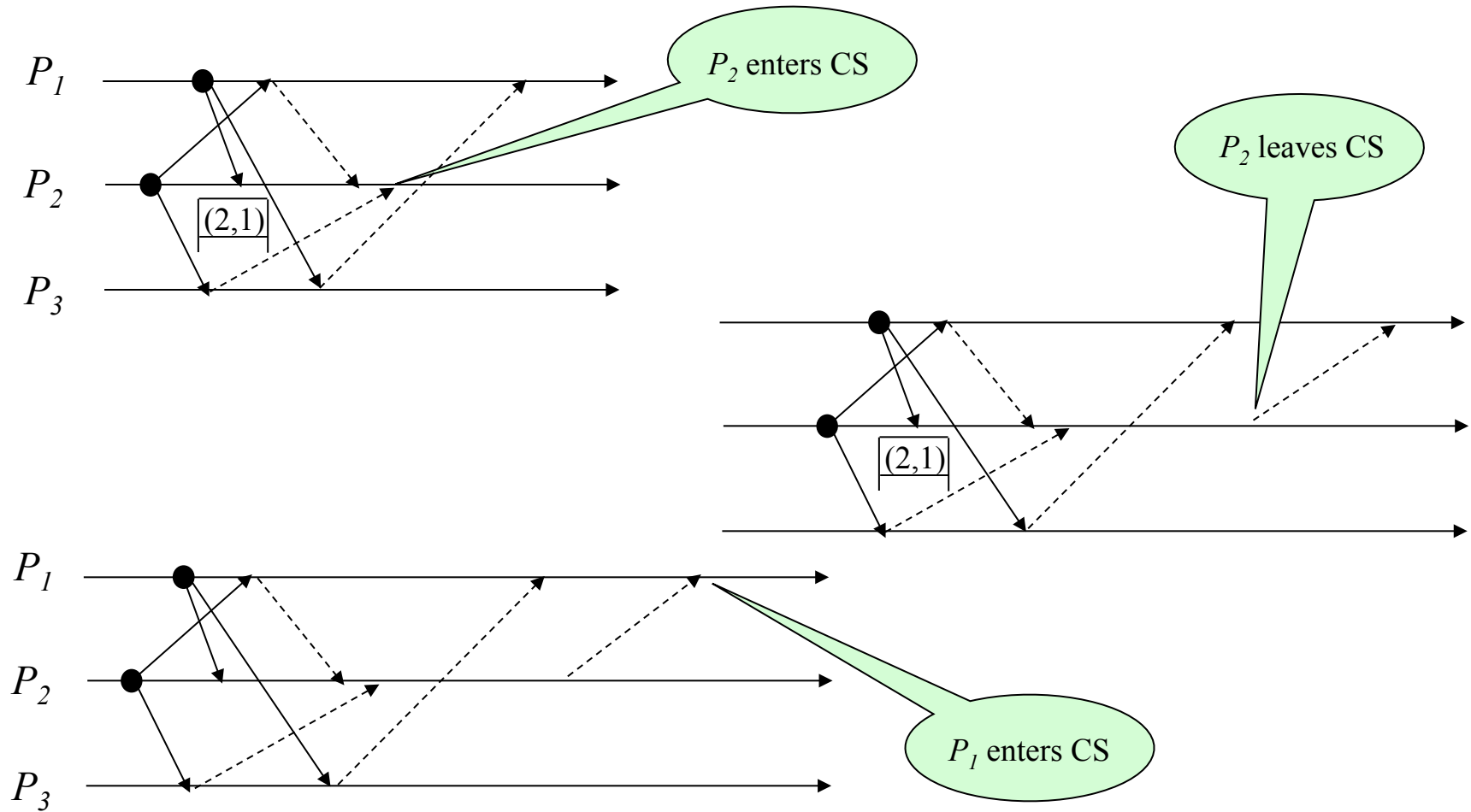
P_i executes the CS only when:

- has received a **REPLY** from everybody

Releasing the CS:

- when done, a process sends a **REPLY** to all deferred requests

Ricart-Agrawala Algorithm Example



Ricart-Agrawala: proof of correctness

- Proof by contradiction:
 - assume P_i and P_j are executing the CS at the same time
 - assume request timestamp of P_i is smaller than that of P_j
 - this means P_i issued its own request first and then received P_j 's request, otherwise P_j request timestamp would be smaller
 - for P_i and P_j to execute the CS concurrently means P_i sent a REPLY to P_j before exiting the CS
 - Contradiction: a process is not allowed to send a REPLY if the timestamp of its request is smaller than the incoming one
- Therefore it cannot be that P_i and P_j are executing the CS at the same time!